IP Addressing - Part 2
Classful Subnetting

Cabrillo College

CIS 81 and CST 311

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Classful IP Addressing

Class A	Network	Host		
Octet	1	2	3	4

Class B	Network		Host	
Octet	1	2	3	4

Class C	Network			Host
Octet	1	2	3	4

Class D	Host			
Octet	1	2	3	4

Address Class	First Octet Range	Number of Possible Networks	Number of Hosts per Network
Class A	0 to 127	128 (2 are reserved)	16,777,214
Class B	128 to 191	16,348	65,534
Class C	192 to 223	2,097,152	254

- In the early days of the Internet, IP addresses were allocated to organizations based on request rather than actual need.
- When an organization received an IP network address, that address was associated with a **"Class", A, B, or C.**
- This is known as **Classful IP Addressing**
- The **first octet** of the address determined what class the network belonged to and which bits were the network bits and which bits were the host bits.
- There were **no** subnet masks.
- It was not until 1992 when the IETF introduced CIDR (Classless Interdomain Routing), making the address class meaning less.
- This is known as **Classless IP Addressing**.
- For now, all you need to know is that today's networks are classless, except for some things like the **structure of Cisco's IP routing table** and for those networks that still use Classful routing protocols.
- You will learn more about this is CIS 82, CIS 83 and CIS 185.

IPv4 Address Classes

Class A	Network	Host		
Octet	1	2	3	4

Class B	Network		Host	
Octet	1	2	3	4

Class C	Network			Host
Octet	1	2	3	4

Class D	Host			
Octet	1	2	3	4

Address Classes

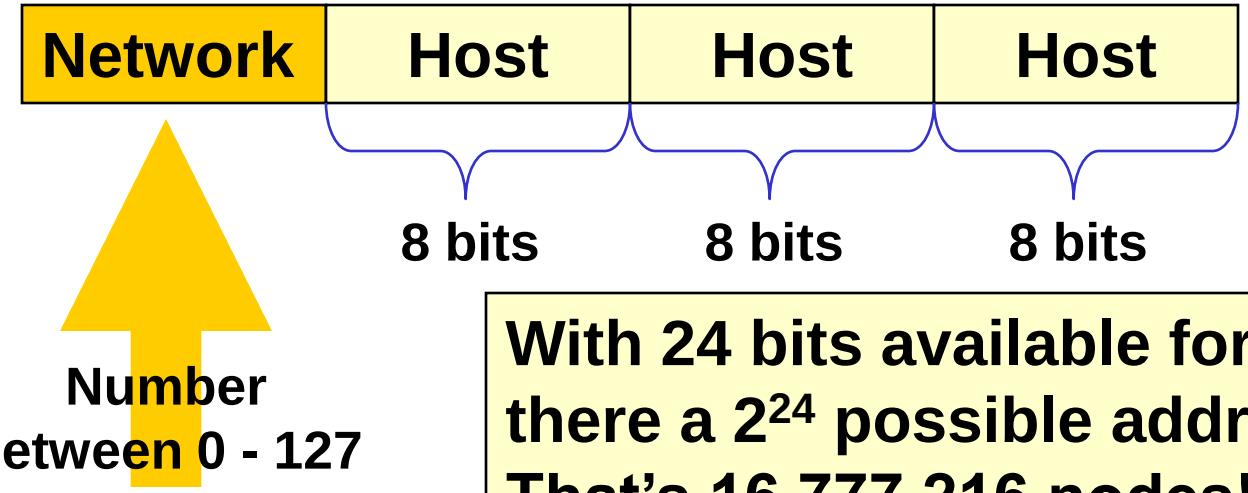
	1st octet	2nd octet	3rd octet	4th octet
Class A	Network	Host	Host	Host
Class B	Network	Network	Host	Host
Class C	Network	Network	Network	Host

N = Network number assigned by ARIN
(American Registry for Internet Numbers)
H = Host number assigned by administrator

Class A addresses

Default Mask: 255.0.0.0 (/8)

First octet is between 0 – 127, begins with 0



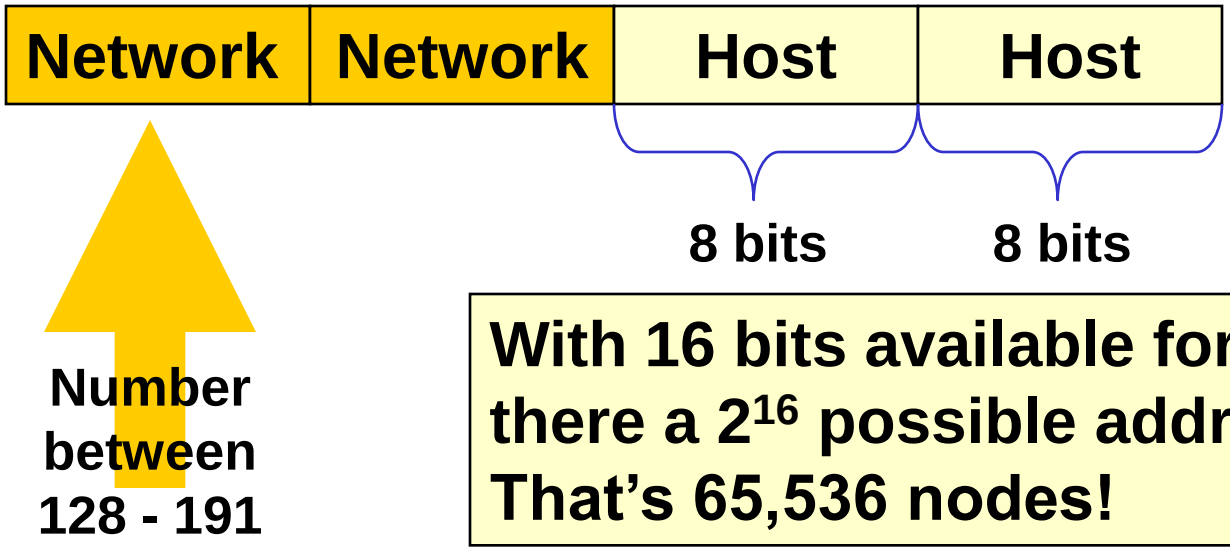
With 24 bits available for hosts, there a 2^{24} possible addresses. That's 16,777,216 nodes!

- There are 126 class A addresses.
  - 0 and 127 have special meaning and are not used.
- 16,777,214 host addresses, one for network address and one for broadcast address.
- Only large organizations such as the military, government agencies, universities, and large corporations have class A addresses.
- For example ISPs have 24.0.0.0 and 63.0.0.0
- Class A addresses account for 2,147,483,648 of the possible IPv4 addresses.
- That's 50 % of the total unicast address space, ***if*** classful was still used in the Internet!

Class B addresses

Default Mask: 255.255.0.0 (/16)

First octet is between 128 – 191, begins with 10



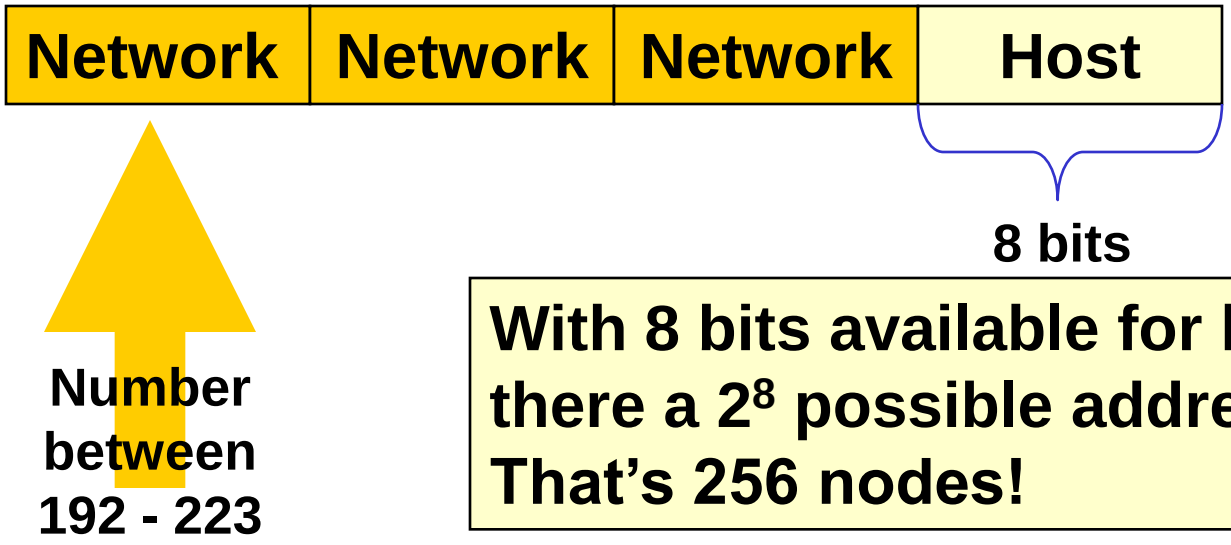
With 16 bits available for hosts, there a 2^{16} possible addresses. That's 65,536 nodes!

- There are 16,384 (2^{14}) class B networks.
- 65,534 host addresses, one for network address and one for broadcast address.
- Class B addresses represent 25% of the total IPv4 unicast address space.
- Class B addresses are assigned to large organizations including corporations (such as Cisco, government agencies, and school districts).

Class C addresses

Default Mask: 255.255.255.0 (/24)

First octet is between 192 – 223, begins with 110



With 8 bits available for hosts, there a 2^8 possible addresses. That's 256 nodes!

- There are 2,097,152 possible class C networks.
- 254 host addresses, one for network address and one for broadcast address.
- Class C addresses represent 12.5% of the total IPv4 unicast address space.

IPv4 Address Classes

Class A	Network	Host		
Octet	1	2	3	4

Class B	Network		Host	
Octet	1	2	3	4

Class C	Network			Host
Octet	1	2	3	4

Class D	Host			
Octet	1	2	3	4

Address Class	First Octet Range	Number of Possible Networks	Number of Hosts per Network
Class A	0 to 127	128 (2 are reserved)	16,777,214
Class B	128 to 191	16,348	65,534
Class C	192 to 223	2,097,152	254

- No medium size host networks
- In the early days of the Internet, IP addresses were allocated to organizations based on request rather than actual need.

Network based on first octet

Address Class	First Octet Range	Number of Possible Networks	Number of Hosts per Network
Class A	0 to 127	128 (2 are reserved)	16,777,214
Class B	128 to 191	16,348	65,534
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- The network portion of the IP address was dependent upon the first octet.
- There was no “Base Network Mask” provided by the ISP.
- The network mask was inherent in the address itself.

IPv4 Address Classes

Address Class	First Octet Range	Number of Possible Networks	Number of Hosts per Network
Class A	0 to 127	128 (2 are reserved)	16,777,214
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Class D Addresses

- A Class D address begins with binary 1110 in the first octet.
- First octet range 224 to 239.
- Class D address can be used to represent a group of hosts called a host group, or multicast group.

Class E Addresses

First octet of an IP address begins with 1111

- Class E addresses are reserved for experimental purposes and should not be used for addressing hosts or multicast groups.

Fill in the information…

1. 192.168.1.3 Class _____ Default Mask:_____
Network: _____ Broadcast: _____
Hosts: _____ through _____

2. 1.12.100.31 Class _____ Default Mask:_____
Network: _____ Broadcast: _____
Hosts: _____ through _____

3. 172.30.77.5 Class _____ Default Mask:_____
Network: _____ Broadcast: _____
Hosts: _____ through _____

Fill in the information…

1. 192.168.1.3 Class C Default Mask: 255.255.255.0
Network: 192.168.1.0 Broadcast: 192.168.1.255
Hosts: 192.168.1.1 through 192.168.1.254

2. 1.12.100.31 Class A Default Mask: 255.0.0.0
Network: 1.0.0.0 Broadcast: 1.255.255.255
Hosts: 1.0.0.1 through 1.255.255.254

3. 172.30.77.5 Class B Default Mask: 255.255.0.0
Network: 172.30.0.0 Broadcast: 172.30.255.255
Hosts: 172.30.0.1. through 172.30.255.254

Class separates network from host bits

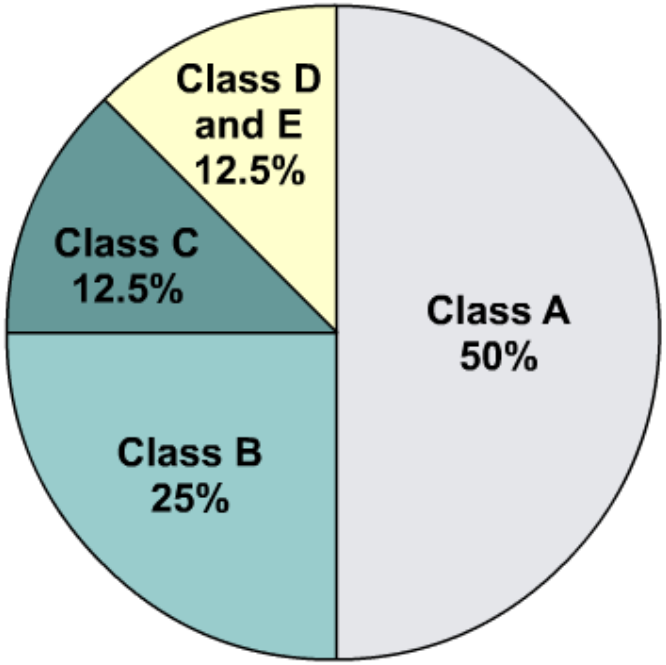
- The Class determines the Base Network Mask!

1. 192.168.1.3 — Class C → Default Mask: 255.255.255.0, Network: 192.168.1.0
2. 1.12.100.31 — Class A → Default Mask: 255.0.0.0, Network: 1.0.0.0
3. 172.30.77.5 — Class B → Default Mask: 255.255.0.0, Network: 172.30.0.0

Know the classes! (Write this out)

Class	First Bits	First Octet	Network Bits	Host Bits
A	0	0 – 127	8	24
B	10	128 - 191	16	16
C	110	192 - 223	24	8
D	1110	224 – 239		
E	1111	240 -		

IP addressing crisis



With Class A and B addresses virtually exhausted, Class C addresses (12.5 percent of the total space) are left to assign to new networks.

- Address Depletion
- Internet Routing Table Explosion

IPv4 Addressing

Subnet Mask

- One solution to the IP address shortage was thought to be the subnet mask.
- Formalized in 1985 (RFC 950), the subnet mask breaks a single class A, B or C network in to smaller pieces.
- This does allow a network administrator to divide their network into subnets.
- Routers still associated an network address with the first octet of the IP address.

All Zeros and All Ones Subnets

Using the All Ones Subnet

- **There is no command to enable or disable the use of the all-ones subnet, it is enabled by default.**

```
Router(config)#ip subnet-zero
```

- **The use of the all-ones subnet has always been explicitly allowed and the use of subnet zero is explicitly allowed since Cisco IOS version 12.0.**

RFC 1878 states**, "This practice (of excluding all-zeros and all-ones subnets) is obsolete! Modern software will be able to utilize all definable networks." Today, the use of subnet zero and the all-ones subnet is generally accepted and most vendors support their use, though, on certain networks, particularly the ones using legacy software, the use of subnet zero and the all-ones subnet can lead to problems.**

CCO: Subnet Zero and the All-Ones Subnet
http://www.cisco.com/en/US/tech/tk648/tk361/technologies_tech_note09186a0080093f18.shtml

Long Term Solution: IPv6 (coming)

- IPv6, or IPng (IP – the Next Generation) uses a 128-bit address space, yielding

  340,282,366,920,938,463,463,374,607,431,768,211,456

  possible addresses.
- IPv6 has been slow to arrive
- IPv6 requires new software; IT staffs must be retrained
- IPv6 will most likely coexist with IPv4 for years to come.
- Some experts believe IPv4 will remain for more than 10 years.

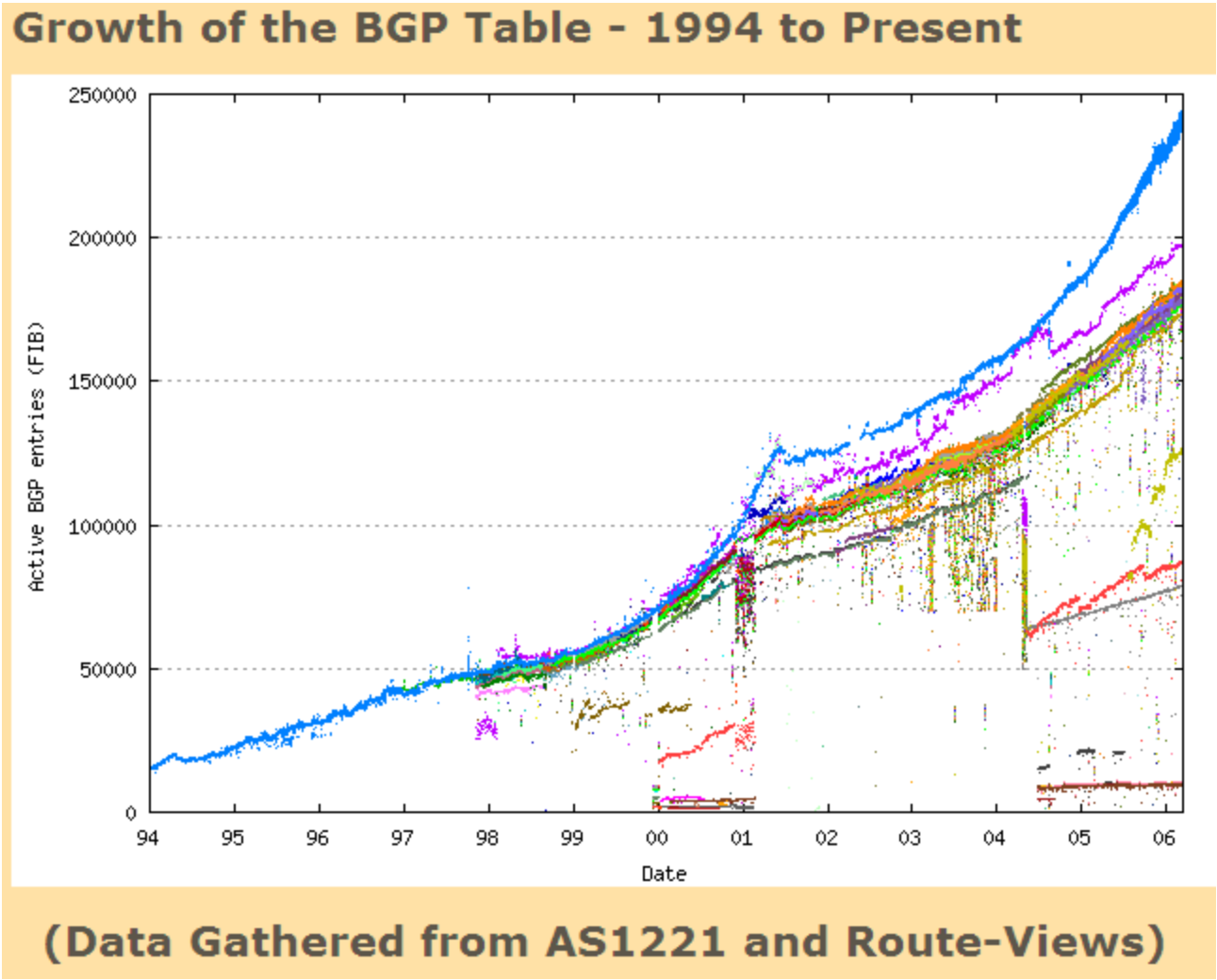
Short Term Solutions: IPv4 Enhancements

Discussed in CIS 83 and CIS 185

- CIDR (Classless Inter-Domain Routing) – RFCs 1517, 1518, 1519, 1520
- VLSM (Variable Length Subnet Mask) – RFC 1009
- Private Addressing - RFC 1918
- NAT/PAT (Network Address Translation / Port Address Translation) – RFC
  - More later when we discuss TCP

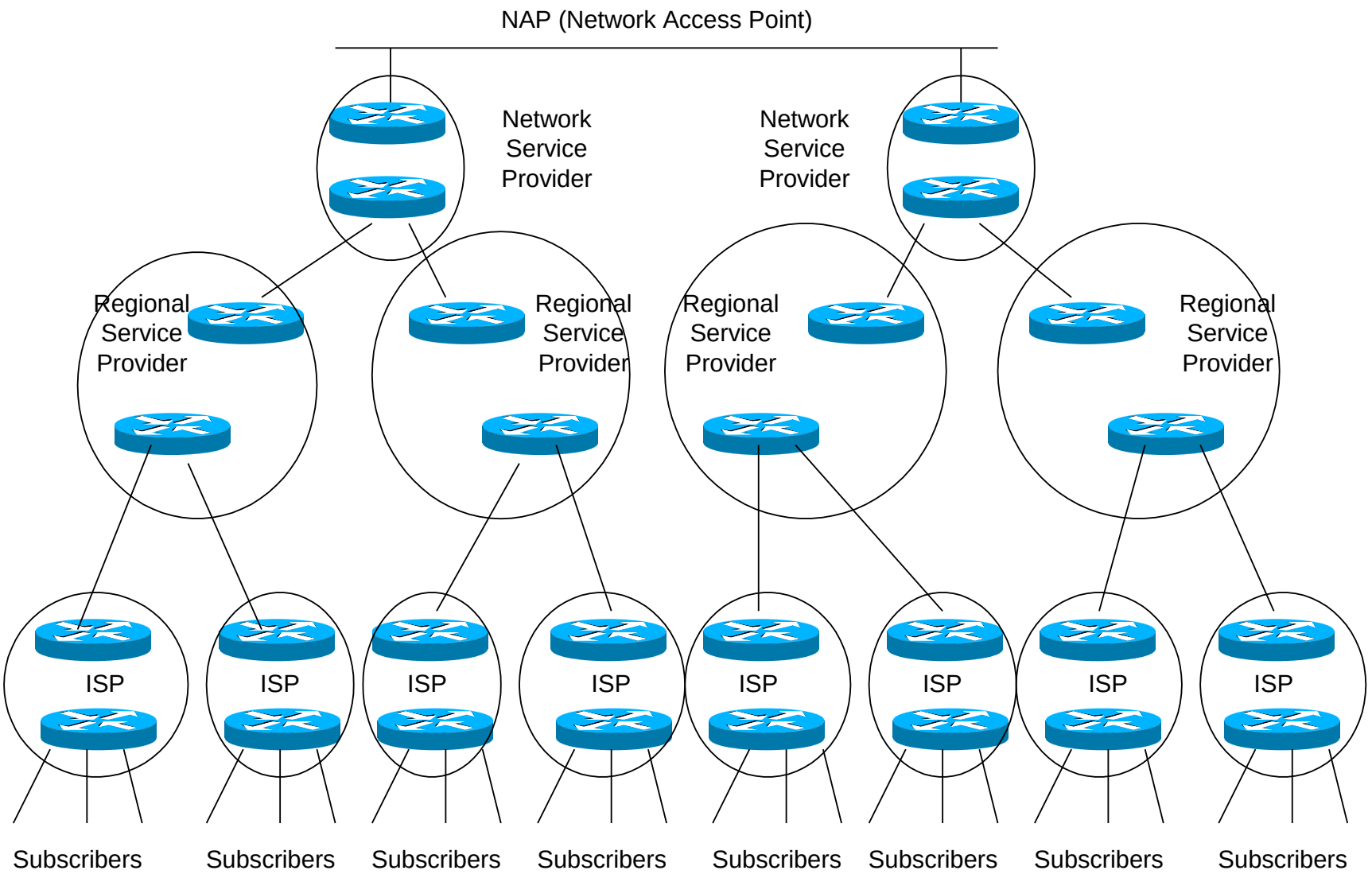
Class	RFC 1918 Internal Address Range	CIDR Prefix
A	10.0.0.0 to 10.255.255.255	10.0.0.0/8
B	172.16.0.0 to 172.31.255.255	172.16.0.0/12
C	192.168.0.0 to 192.168.255.255	192.168.0.0/16

Active BGP entries – March, 2006



http://bgp.potaroo.net/

ISP/NAP Hierarchy - "The Internet: Still hierarchical after all these years." Jeff Doyle *(Tries to be anyways!)*



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